

THE
DESCRIPTION and USE
OF THE
Astronomical Rotula.

SHEWING

The CHANGE and AGE of the MOON, the
MOTIONS and PLACES of the SUN, MOON,
and NODES in the ECLIPTIC; with the
TIMES and PHASES of all the SOLAR and
LUNAR ECLIPSES.

By *JAMES FERGUSON*, F.R.S.

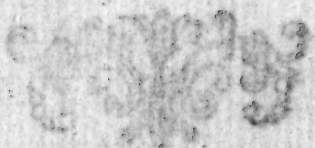


L O N D O N :

Printed in the Year MDCCLXXV.

THE
DESCRIPTION AND USE
OF THE
Astronomical Rods.

BY
JAMES P. KESSELY, F.R.S.
OF THE
MUSEUM OF
NATURAL HISTORY
AND
ASTRONOMY
IN THE
ROYAL SOCIETY
OF LONDON.



LONDON:
Printed by J. JOHNSON, in Pall Mall.

(4)

THE DESCRIPTION and USE OF THE Astronomical Rotula.

THIS Instrument consists of five Plates, the largest of which we shall always call *the first Plate*, the next in Size *the second Plate*, the next *the third*, and so on to *the fifth*, which is the uppermost, and least.

1. The first Plate contains only a Circle of Months divided into their respective Days. Its Use is, to find the Days of all the New and Full Moons in any given Year; and also the Moon's Age on any given Day, by Means of

2. The second Plate, on which all the New Moons are marked thus, ●; the Full Moons thus, ○; and from every New Moon to the next, there are $29\frac{1}{2}$ Days, except the last in the Year, from which there are only 11; because twelve Lunations, and 11 Days over, make a Year. The New Moon in this Circle, which has the Finger pointing to it, is always to be reckoned the first New Moon in the Year.

Within this Circle of Moons is a spiral Line of three Revolutions, in which are inserted all the Years of Christ from 1752 to 1800 *inclusive*. Every Year in this Spiral stands over as much of

the *Ecliptic*, or Circle of Signs, as the *Ascending Node* of the *Moon's Orbit* moves through in a Year, which is $19\frac{1}{7}$ Degrees backward, or contrary to the Order of Signs: And each Year is divided into twelve Parts by Dots, which signify the Beginning of its respective Months; the Space from Dot to Dot being equal to the Motion of the Node in a Month.—The Year begins with *January*; and the Dot on the End of the cross Line next the Date of the Year, stands for the Beginning of *January*; the next for the Beginning of *February*, and so on.

Within this *Spiral of Years* is a Circle of 12 Signs, which are the Signs of the *Ecliptic*; each Sign containing 30 equal Parts or Degrees: And within this is a Circle of 12 Months, so divided into their respective Days, that each Day stands under the Degree of the *Ecliptic* in which the Sun is on that Day. The Use of these two Circles is for finding the *Sun's Place* in the *Ecliptic* on any given Day of the Year.

3. The third Plate has the *Moon's Ascending* and *Descending Nodes* marked upon it; and also a Circle divided into the Degrees of the *Moon's Latitude*, which amount to $5\frac{1}{2}$, at the middle Points between the Nodes. The Moon being on the *North Side* of the *Ecliptic*, whilst she is going from the *Ascending Node* to the *Descending*, is said to have *North Latitude* all that Time: And *South Latitude* whilst she is going from the *Descending Node* to the *Ascending*, because she is then on the *South Side* of the *Ecliptic*. So that the Moon is never in the Plane of the *Ecliptic* but when she is in her Nodes, which happens twice in every Luration, and in some thrice. A little beyond the *first Degree* of the *Moon's Latitude*, is engraved a small Moon, at 12 Degrees Distance from each

each Node; which is the greatest Distance from the Node that the Moon can be eclipsed at. And near the *second Degree* of the Moon's Latitude is engraved a small Sun, at 18 Degrees from each Node, which is the greatest Distance from the Node that the Sun can be eclipsed at. From this Plate proceeds an Index, marked ASCENDING NODE; the straight Edge of which, is for finding the *Place of that Node* in the Ecliptic.

4. On the fourth Plate is a Circle divided into $29\frac{1}{2}$ equal Parts, which are the Days of the Moon's Age, accounted from the Time of any particular New Moon to the next following one. These Divisions begin at the New Moon, marked thus ● on the Plate, from which proceeds an Index marked *Sun's Place*. By these Divisions, and an Index on the fifth Plate, marked *Moon's Place*, the Moon's Place in the Ecliptic is found for any given Day of her Age. N. B. The straight Edges of these Indexes, which lie in a right Line with the Center of the Instrument, are always to be regarded in setting them according to the following Directions.

5. On the fifth, or uppermost Plate, are two Tables; one of which shews the Dominical Letter, and mean Time of the first New Moon in the Year (*viz.* in *January*) from 1752 to 1800. In this Table, *M* signifies Morning, and *A* Afternoon. Thus, *A. D.* 1764, the first New Moon is on the 3d of *January*, at 7 o'Clock in the Afternoon; and the Dominical Letter is *AG*, the first of which Letters serves for *January* and *February*, and the last for all the rest of the Year. The other Table is for finding the Day of the Month answering to any Day of the Week, by the Dominical Letter. Between these Tables are two round Holes, one marked *SUN*, and the other *MOON*; the former of which

which is for shewing the Types or Phases of *Solar Eclipses*; and the latter for shewing those of the *Lunar*.

[When the Reader is so far Master of this Description, as to find the Plates and Circles readily, which he may do in less than half an Hour, he may proceed to the Use of the *Rotula* as shewn in the following Problems.]

PROB. I. *To find the Day of the Month answering to any given Day of the Week.*

Find the Dominical Letter for the given Year on the fifth Plate; then, all the Days of the Months under the same Letter in the other Table on that Plate are *Sundays*, in the Divisions of the Months; which being once known, the rest are easily found.

EXAMPLE. For the *Sundays* in *March* 1764. For this and the following Months I find (as in §. 5.) that the Dominical Letter is G; therefore, I look in the Column under G, in the Table shewing the Days of the Months; and under that Letter, in the Division of *March*, I find that the 4th, 11th, 18th, and 25th Days, are all *Sundays* in that Month: Consequently the 5th, 12th, 19th, and 26th Days, are *Mondays*; the next following ones are *Tuesdays*, and so on.

PROB. II. *To find the Days of all the New and Full Moons in any given Year, from 1752 to 1800.*

Find the mean Time of New Moon in *January* for the given Year, by the Table on the uppermost Plate; (§. 5.) and to that Time in *January*, on the first Plate, set the New Moon that has the Finger pointing to it on the second Plate, (§. 1. and 2.) and then, all the New and Full Moons in that

that Year, will stand on the second Plate, against the Days of the Months on which they happen, in the first Plate. *N. B.* In Leap Years, after *February*, the New Moon pointed out by the Finger must be set to the Day next before that on which it really falls in *January*; otherwise, all the New Moons after *February* would be shewn one Day too late in the Instrument, on Account of the intercalary Day at the End of that Month.

EXAMPLE. In the Year 1760, which is a Leap Year, I find by the Table on the fifth Plate that the mean Time of New Moon in *January* is on the 17th Day, at 7 o'Clock in the Afternoon: Therefore, I set the New Moon with the Finger pointing to it on the second Plate to the 17th of *January* on the first Plate, a little past the Division Line which marks that Day, because that Line always signifies the Noon of the Day; and this New Moon happens in the Afternoon. Then I find that the next New Moon falls about Noon on the 16th of *February*; the third would fall in the Afternoon on the 17th of *March*; but this, being in a Leap Year, is one Day too late: Therefore I set the New Moon in *January* one Day backward; and then the New Moon in *March* falls on the 16th Day in the Afternoon, which is the right mean Time thereof. The fourth New Moon falls on the 15th of *April* about Noon; the fifth falls on the 14th of *May* in the Afternoon; and so on to the last in the Year, which is on the 7th of *December*.—In the same Manner I find, that the mean Time of the first Full Moon in the same Year was on the first Day of *February*, in the Afternoon; the second Full Moon fell about Noon on the second Day of *March*; the third about Midnight, between the last Day of *March* and first of *April*; and so on to the End of the Year.—This Instrument

shews only the mean Times of New and Full Moons, which often differ ten or twelve Hours from the true calculated Times thereof, as shewn by Almanacks.

PROB. III. *To find the Age of the Moon on any Day of a given Year.*

The Instrument remaining as in the last Problem, each Day of the Year on the first Plate stands over the Day of the Moon's Age on the Edge of the second Plate. Thus, in the Year 1760, I find the 20th of *April* answers to the 5th Day of the Moon; the 20th of *June* to the 7th, &c.

PROB. IV. *To find the Place of the Moon's Ascending Node on any Day of a given Year, from 1752 to 1800.*

Look for the given Year in the Spiral of Years on the second Plate, (§. 2.) and, in the Space allotted for that Year, count among the Dots (beginning with *January*) until you come to the given Month; Then, in the little Space included between the two Dots which limit that Month, set the straight Edge of the *Ascending Node Index*, (§. 3. toward the End) as near as you can guess, to the given Day of that Month, which will be near enough for the Node; and then, the same Edge of the Index will cut the Place of the *Ascending Node* in the Circle of Signs; to which, the Place of the *Descending Node* (marked *Des. Nod.*) is opposite.

EXAMPLE. Suppose the Place of the *Ascending Node* to be required for the first of *April*, in the Year 1764: I look in the Spiral of Years for that Dot which begins *April* in the Year 1764, and upon setting the straight Edge of the *Node-Index* to it, I find the same Edge cuts $4\frac{1}{2}$ Degrees of

Aries

Aries in the Circle of Signs: So the Moon's Ascending Node is then in $4\frac{1}{2}$ Degrees of *Aries*; and consequently her Descending Node is in $4\frac{1}{2}$ Degrees of *Libra*.

PROB. V. *To find the Sun's Place in the Ecliptic on any given Day of the Year.*

Look for the given Day in the Circle of Months on the second Plate, (§. 2. towards the End) and set the straight Edge of the Index marked *Sun's Place* to that Day; then, the same Edge of the Index will cut the Sun's Place in the Circle of Signs.

EXAMPLE. Suppose the Sun's Place be required for the first Day of *April*: Upon setting the Index to that Day in the Circle of Months, I find it cuts $11\frac{1}{4}$ Degrees of *Aries*, which is the Sun's Place on that Day, at Noon.

PROB. VI. *To find the Moon's Place in her Orbit, and her Latitude or Declination from the Ecliptic, on any given Day of the Year.*

Having, for the given Day, found the Place of the Ascending Node, and set its Index thereto, as in the fourth Problem; and the Day of the Moon's Age, by the third; and also the Sun's Place for that Day, by the fifth Problem; keep both these Indexes at their proper Places in the Circle of Signs: Then, set the Index marked *Moon's Place* to the Day of her Age in the Circle of $29\frac{1}{2}$ equal Parts on the fourth Plate, and that Index will cut the Moon's Place in the Circle of Signs on the second Plate, and at the same Time her Latitude on the Edge of the third.

EXAMPLE. Suppose the Moon's Place and Latitude be required for the 25th of *April* 1760, on which Day I find, according to Prob. 3. that the Moon is ten Days old; and that, according to Prob.

Prob. 5. the Sun's Place is in the 5th Degree of *Taurus*; and by Prob. 4. that the Place of the Ascending Node is in the 21st Degree of *Gemini*. I set the Node-Index to the 21st of *Gemini*, and the Sun's Place-Index to the 5th of *Taurus*: Keeping these two Indexes at their Places in the Circle of Signs, I set the Index marked *Moon's Place* to the 10th Day of her Age in the Circle of 29 $\frac{1}{2}$ equal Parts; and then I find it cuts the 8th Degree of *Virgo*, which is the Moon's mean Place on that Day at Noon; and at the same Time this Index cuts a little beyond 5 Degrees on the Edge of the third Plate, which is the Moon's [*North*] Latitude on that Day. *N. B.* The Moon's Latitude is always *North* whilst she is going from her Ascending Node to her Descending Node; and *South* whilst she is going from her Descending Node to her Ascending Node.

PROB. VII. *To find the Distance of the Sun and Moon from each other, and from either of the Nodes, on any given Day of the Year.*

This is easily found, by counting the Number of Degrees in the Circle of Signs which are intercepted between the respective Indexes of the Node, Sun and Moon, when they are set to their proper Places as above directed; and needs no Example.

PROB. VIII. *To find when the Sun will be in Conjunction with the Moon's Nodes, in any given Year.*

Move the Ascending Node-Index till it comes into the given Year in the Spiral of Years on the second Plate, and then see what Month it cuts in the Circle of Months on that Plate: This done, set the Node-Index to the same Month in the given Year among the Dots; and then, by moving it a little backwards or forwards in the small Space allotted

allotted for that Month between the Dots, you will soon find that it will cut the same Day in the Circle of Months which answers to the Day (as near as you can guess) between the two Dots which limit the same Month in the Spiral; and *that* is the Day on which the Sun is in Conjunction with the Moon's Ascending Node. This being found, move the same Node backward till it cuts the same Month and Day in the Spiral of Years that stands right against the Descending Node in the Circle of Months; and *that* will be the Day of the Sun's Conjunction with the Descending Node.

EXAMPLE. Let the Days of the Sun's Conjunction with the Nodes be required in the Year 1764. I first bring the Ascending Node-Index into the Year 1764 in the Spiral of Years, and then I find that it falls into *March* in the Circle of Months within the Spiral; hence I conclude, that the Sun will be in Conjunction with the Ascending Node on some Day in *March*: Therefore, to find the Day, I set the Node-Index between the two Dots which begin *March* and *April* 1764 in the Spiral; and then, by moving the Index backwards and forwards in that small Space, I find that the 25th of *March* in the Circle of Months, and the like Time between the two Dots which limit the same Month in the Spiral, is the only Time that the Index will cut at once in both: Therefore the Sun will be in Conjunction with the Ascending Node on the 25th of *March* 1764; and at the same Time, the Descending Node will be opposite to the Sun: The Earth being always in a right Line between the Moon's Nodes.

To find when the Sun will be in Conjunction with the Descending Node, I move the Ascending Node backwards in the Circle of Signs, until I find it cuts the same Time in the Year 1764 in the Spiral,

Spiral, that stands against the Descending Node in the Circle of Months; and I find by Trial, that the only Time which answers thereto, is the 18th of *September*; and therefore conclude, that the Sun will be in Conjunction with the Moon's Descending Node on the 18th of *September* 1764.

The Nodes move backward, or contrary to the Order of Signs, at the mean Rate of $19\frac{1}{2}$ Degrees every Year, which answers to $19\frac{1}{2}$ Days in the Circle of Months; and therefore the Conjunctions of the Sun and Nodes happen so much sooner every Year than they did in the Year before.

PROB. IX. *To find on what Days of a given Year the Sun and Moon will be eclipsed, and to shew the Types or Appearances of these Eclipses.*

Find by Prob. 8. the Days of the given Year on which the Sun is in Conjunction with the Moon's Nodes; then, at all those Changes of the Moon which happen within 18 Days, either before or after the Sun's Conjunction with the Nodes, the Sun will be eclipsed; but at no Change without that Limit. And at all those Full Moons which happen within 12 Days either before or after the Sun's Conjunction with the Nodes, the Moon will be eclipsed. The Times of these New and Full Moons are easily found by Prob. 2. A right Line supposed to be drawn through both the Nodes will point towards the Sun twice every Year; and in some Years thrice. For, as the Nodes move backward $19\frac{1}{2}$ Degrees every Year, it is plain that the Sun will pass by each Node once a Year at least; and in the next Year he will pass by them 19 Days sooner. Therefore, when he passes by either of them (suppose the Ascending) any Time before the 19th of *January*, which he will do in the Year 1768, he will pass by the other

other in *July*; and come again to the former about the End of *December*, on account of its retrograde Motion.

Now, to shew the Type or Phasis of a Solar Eclipse, having found at what New Moon it must be, set the Ascending Node-Index, as near as you can guess, to the Time of that New Moon in the Spiral of Years; and keeping it there, bring the two Indexes marked *Sun's Place* and *Moon's Place* to the Day of that New Moon, in the Circle of Months on the second Plate; and the Type or Figure of that Eclipse will appear through the round Hole marked *SUN*, in the fifth Plate. If the Eclipse be invisible on the *North* Side of the Equator, no black will appear through the Hole; only the three Letters *Inv.* will be seen.

To shew the Type, Figure or Quantity of a Lunar Eclipse, first find, as above directed, at what Full Moon it must be; then, set the Ascending Node-Index to that Time in the Spiral of Years, and keeping it there, bring the Sun's Place-Index to the Day of that Full Moon in the Circle of Months on the second Plate: Keeping it there also, bring the Moon's Place-Index to the Full Moon, marked *F*, near the 15th Day of the Moon's Age on the fourth Plate; and then the Moon's Place-Index will be directly opposite to the Sun's, and the Type of the Eclipse will appear through the round Hole marked *MOON* on the fifth Plate; and will shew whether that Eclipse be total or partial, as the whole Hole, or only Part of it, is darkened.

EXAMPLE. For one Eclipse of the Sun, and one of the Moon, in the Year 1764. I find by Prob. 8. that the Sun will be in Conjunction with the Ascending Node on the 25th of *March* in that Year; and by working as directed in Prob. 2.

I find

I find that the Moon will change on the first of *April*; which being less than 18 Days after the Sun's Conjunction with the Node, the Sun must be eclipsed at the Time of that Change. Now, to find what Sort of an Eclipse that must be, I first set the Ascending Node-Index to the Dot which begins *April 1764* in the Spiral of Years on the second Plate; keeping it there, I bring the two Indexes marked *Sun's Place* and *Moon's Place* to the first Day of *April* in the Circle of Months within the Spiral; and then, looking at the round Hole marked *SUN*, in the fifth Plate, I find almost the Whole of it darkened; which shews that there will be a very remarkable Eclipse of the Sun on that Day.

The second Plate of the Instrument being rectified as directed in Prob. 2. I find that one of the Full Moons in the Year 1764 falls between the 17th and 18th Days of *March*; which being within 12 Days of the above Conjunction of the Sun and Node, viz. *March 25th*, the Moon must be eclipsed at that Full. Therefore, to shew the Figure or Magnitude of that Eclipse, I first set the Ascending Node-Index, as near as I can guess, to the 17th or 18th of *March 1764*, in the Spiral of Years on the second Plate: Keeping it there, I set the Sun's Place-Index between the 17th and 18th of *March* in the Circle of Months within the Spiral; and keeping it there also, I bring the Moon's Place-Index to the Middle of the Full Moon marked *F*, near the 15th Day of the Moon's Age, on the fourth Plate: Then these two Indexes are opposite to each other in the Circle of Signs (as the Sun and Moon are opposite to each other at the Time of Full Moon) and looking at the round Hole marked *MOON*, in the fifth Plate, I find that about two Thirds of it is darkened; which shews that

that there will be so much of the Moon eclipsed by the Earth's Shadow at that Time.

As it appears, by the eighth Problem, that the Sun will be in Conjunction with the Moon's Descending Node on the 18th of *September* 1764; and by working as directed in the second Problem, I find that the Moon will change between the 24th and 25th of *September* in that Year, which being less than 18 Days from the Sun's Conjunction with the Descending Node, the Sun will be eclipsed on that Day. And the Moon being Full on the 10th of *September* that Year, which is less than 12 Days from the Time of the Sun's Conjunction with the Descending Node, she must necessarily be eclipsed at that Full.—And as there are but two New Moons and two Full Moons which happen within the above Limits (§. 3.) in the Year 1764, there can be no more than two Eclipses of the Sun and two of the Moon in that Year.

Because each particular Eclipse of the Moon has the same Appearance at all those Parts of the Earth where it is seen, this Instrument may be depended on for shewing the Magnitude of any Eclipse of the Moon: But it cannot be so well trusted to in shewing the Phases of Solar Eclipses, although it may for their mean Times; for these Phases are so different at different places of the Earth, that they cannot be ascertained without having recourse to long and tedious Calculations.

Published

Published by Mr. FERGUSON.

1. **L**ECTURES on Select Subjects in Mechanics, Hydrostatics, Hydraulics, Pneumatics, Optics, the Use of the Globes, and Art of Dialling, *Quarto*, 14s. *Octavo*, 9s.

2. ASTRONOMY explained upon Sir ISAAC NEWTON's Principles, and made easy to those who have not studied the Mathematics. *Quarto*, 18s. *Octavo*, 9s.

3. THE Young GENTLEMAN and LADY's Astronomy. *Octavo*, 5s.

4. TABLES and TRACTS relative to several Arts, and Sciences. *Octavo*, 3s.

5 AN Introduction to ELECTRICITY. *Octavo*, 5s.

6. SELECT MECHANICAL EXERCISES, shewing how to make Astronomical Clocks, Orreries, Sun-Dials, &c. *Octavo*, 5s.

4 OC 58

7. THE ASTRONOMICAL ROTULA, here described, 5s. 6d.

8. A NEW ASTRONOMICAL INSTRUMENT, shewing all the Problems of the ROTULA, except the Eclipses; and instead thereof, the Times of the Rising and Setting of the Sun, Moon, and Stars. 5s. 6d.

9. THE ASTRONOMICAL TIME-KEEPER. Shewing how to find the true Time of the Night by the Fixed Stars, in all Latitudes. 5s. 6d.

All sold by Mr. CADELL, Bookseller, in the Strand, London.

